Investigations of Structural Controls and Mineralogic Associations of Chlorine-36 Fast Pathways in the ESF

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Abstract

The occurrence of bomb-pulse chlorine-36 (^{36}Cl) in the underground Exploratory Studies Facility (ESF) at Yucca Mountain indicates flow paths capable of transmitting infiltration from the surface to depths as much as 300 m in less than 50 years. As of March 1997, 189 ^{36}Cl analyses are available for 173 ESF sample locations between Sta. 2 and 68. Most samples have ^{36}Cl/Cl signals well within the range of meteoric background levels. At a few discrete locations, however, the levels extend well above this range, indicating the presence of a component of bomb-pulse ^{36}Cl, i.e., evidence of fast paths. As yet, none of the 53 samples from beyond Sta. 45 contain unambiguous levels of bomb-pulse ^{36}Cl.

Fast pathways at Yucca Mountain appear distinctive in terms of their structural settings and the associated hydrologic properties of those structures. The primary controls on their distribution in the ESF are: 1) the presence of faults that cut the PTn hydrogeologic unit; 2) the magnitude of surface infiltration; and 3) structural features that result in lateral diversion of flow away from fault zones. Bomb-pulse ^{36}Cl values are associated with a variety of fault types, including a block-bounding fault, a probable strike-slip, and smaller, intrablock faults. There appears to be no association between the presence or absence of bomb-pulse ^{36}Cl and the type of fault, the orientation of the fault, or the amount of offset along the fault. The Sundance fault exemplifies a transmissive structural feature with lateral diversion of flow. Lateral diversion of flow below the level of the PTn hydrogeologic unit is most likely within the middle nonlithophysal zone of the Topopah Spring Tuff where large, closely spaced cooling joints and the presence of gently dipping cooling joints promote fracture network connectivity in the rock mass surrounding the fault.

Mineralogic and petrologic analysis of 39 samples in the ^{36}Cl data base suggest that fast pathways may have some subtly distinctive characteristics. Calcite, a common mineral in the ESF, is even more common in bomb-pulse samples. Opal appears to be less common in fast pathways than its overall abundance in the ESF would suggest. Clay deposits that coat fractures or breccia clasts result from aqueous transport of fine clay particles within the fracture network. There is no consistent connection between fast paths and the presence of clay/mordenite, but fast-path sites associated with the Sundance fault commonly contain clay/mordenite.

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